Baseline Comparison System (BCS) SLI Technology Workshop

SLI Technology Workshop

July 17, 2001

Jeff Morton/Mike Nix
MSFC/TD53
(With Contributions From Doug Morris and Richard Brown, RAA, LaRC)

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

RM&S Data and SLI Goals

Increased Safety and Reliability and Reduced Recurring Cost

- It has been clearly articulated by, among others, MSFC Director Art Stephenson that we must fully understand our current reusable launch system in order to develop its successor
- System Reliability, Maintainability and Supportability are the **critical elements** in obtaining SLI goals - unless these are the **primary considerations** in design and development, these goals will remain beyond reach.
- The question arises, what do we know about these inherent characteristics in the Shuttle

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Shuttle RM&S Data Collection Background

Efforts to collect and analyze Shuttle data pertinent to RM&S date back to 1981 with the USAF collecting high level processing time, MTBM and MTTR data on the first 5 flights.

Through 1992 no consistent collection and analysis process directed towards RM&S was emplaced though several disconnected activities occurred. Limitations of PRACA and similar databases for RM&S are discussed later.

In 1992 the first extensive RM&S database based on PRACA began, dealing with maintenance action frequency by subsystem and headcount and continues through the present. The 1994 Access to Space Annual Recurring Cost Backup Report was the first and only to deal with manpower and material cost by budget category. In 1994 a multi-center effort to identify existing data and additional data requirements began and in 1995 a report on available data was published. Coordinated inter-center efforts to establish RM&S data collection continue. Details in backup charts.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Shuttle Data Collection Investigation

- "Available Shuttle System Database Identification and Pathfinder RM&S Data Search" - May 31, 1995. (Copies available)
- Assessment of NASA's then current maintenance data collection procedures and the relative utility of the information for RM&S analyses.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

STS Database Systems

Only three of the major KSC database systems contain information that **could be used** in RM&S analyses. These three systems were all contained within the Integrated Work Control System (IWCS).

1. Integrated Operations System (IOS)
2. Problem Reporting and Corrective Action System (PRACA)
3. Shop Floor Control Data Collection (SFCDC)

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

IOS
(Integrated Operations System)

- IOS is a subset of the "Computer Aided Scheduling and Planning Resources and Planning Resources" (CASPR)
- The IOS system handles the identification, scheduling, release tracking, and statusing of scheduled and unscheduled work and associated authorization documents. ***This system provides the linkage between PRACA and associated data residing within the SFC/DC database.***
- LaRC is working with the PRACA/IOS/SFC data for flights 50 to 90. IOS provides a only tenuous link between PRACA and SFC and the current data has PRACA reports without supporting SFC data due to an inability of MS Access to link the tables. Use of the KSC PRACA reports will require effort to associate those records with the vehicle WBS (courtesy of Richard W. Brown, LaRC.)

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

PRACA System
(Problem Reporting and Corrective Action)

- PRACA is a portion of the larger "Automated Requirements Management System" (ARMS)

- The PRACA database provides an on-line means of initiating, maintaining, tracking, and closing nonconformance problem reports.
  - Note that PRACA is somewhat different that the recommend Failure Reporting and Corrective Action System (FRACAS) normally used in RM&S data collection activities. (PRACA report can not be associated directly with a catastrophic failure. For example, while the Induced Environmental Protection system reflects very high maintenance (~70,000 entries), the Engines (~8000 entries) are the greater reliability concern (courtesy of Dick Brown, LaRC.))

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

SFCDC System
(Shop Floor Control Data Collection)

- The SFCDC system is a portion of the "Shop Floor Control System" (SFC).
- The SFCDC database provides a means of collecting data on work being performed by "hands on" technicians on the shop floor.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Inherent Limitation in Current System

The major problem, from an RM&S perspective, with the KSC data systems is that they are designed to insure that maintenance is complete, not to collect statistical data like MTTR and MTBF. The PRACA data is of little value, in its current state, for the purposes of RM&S analysis since it does not track the history of each "box" to determine the MTBF, and reflects MDT rather than MTTR.

(Courtesy Dick Brown, LaRC)

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

SUMMARY OF CURRENT RM&S DATA STATUS

- "Operations" (RM&S) as an analysis discipline is primarily **empirically based**.
- For **credible analysis** of future system requirements O&S data is required. Must know where we are now to be able to measure the value of new systems, technologies and processes.
- Currently our sources are disparate and provide data at levels not consistent with our needs. Generally **too high** and against a WBS that **does not allow us to follow** the costs.
- A **single source** of data that has been **"appropriately filtered"** needs to be available so that all users could draw on a **consistent source of information** for analysis.
- **Need to start** collecting to **avoid losing more** data that is a **valuable resource** for future launch systems.
- **Need to match** the data to our tools and our tools to the data.

(Courtesy of Doug Morris, LaRC)

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Baseline Comparison System (BCS)
A Response to A Need

- The data required to support Reliability and Maintainability analyses utilizing the STS in support of 2nd Gen are available **at least in part** in government and industry databases but are **difficult to access** in an effective integrated manner. The intent of the BCS development effort is to provide an electronic data system that can **selectively collect and aggregate** the information from these disparate databases into a **single source** of launch vehicle and aircraft information. This single electronic data system is referred to as the Baseline Comparison System (BCS).
  - This work is intended to establish a BCS database on a MSFC VRC server complete with **automated, selective data collection** capability. This capability will be used to populate the BCS with data from all STS flights to date. The automated data collection capability will allow relatively easy updating of the BCS so that it stays current.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Baseline Comparison System (BCS)

- The Baseline Comparison System (BCS) is an effort to develop a system that **aggregates disparate databases** into a single source of launch vehicle and aircraft information.
- BCS is an attempt to make some use of a set of systems that were **not designed** for the task of R&M analyses.
- BCS ***goal*** by November 30, 2001 is to populate the BCS with all **available** relevant R&M data from all STS flights to date.
- BCS has some limited data from aircraft and ELV systems.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

BCS Limitations

- Phase I prototype contains data from only three STS flights (STS 64, 65, and 68) and some limited ELV and aircraft data.

- Orbiter systems **"power-on time"** is recorded differently (ie, **estimated** % of total hours vs **actual** recorded ground & flight power-on time), dependent on various directorate requirements and methodology. This was identified as a major problem in the 1995 R&M study.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

BCS Limitations

- Limitations within the KSC database network include the **lack** of **"direct" traceability to time/MTTR** and subsequent labor hour/cost data. Detailed **task breakouts** are not available through database systems in terms of differentiating inspection time, repair time, etc.

- Objective is **maximum practical** automation. Complete automation of entire BCS updating process (at least in the near term) unlikely. Man in the loop may be preferred during the update process for troubleshooting, etc.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

BCS Status

- Phase I originally included having the current version (3 flight dataset) BCS installed in the MSFC Virtual Research Center (VRC) and internet accessible
- Scope reduced. No installation of BCS to the VRC - judged to be premature. Cost savings carried over to Phase II effort.
- Reduced scope Phase I complete and deliverables have been received and are under review.
- Phase II synopsis is out on Commerce Business Daily (CBD).
- Contract should be awarded by August 1

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Questions/Issues

- What changes have been made since the 1995 R&M study? Several groups including the Inter-center Operations Analysis Team (ICOAT) investigating.
- Is there useful data outside the current database system and can we access it?
- Should the current systems be augmented in the manner of a DOD system (recommended in the 1995 R&M study)?
    - 1995 R&M study claimed there would be a cost savings as well as an enhanced R&M analysis capability.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Recommendations

- Identify and make available all data collected at KSC outside the known databases (if any)

- Implement changes appropriate for adequate data acquisition so that 2nd Gen can benefit as much as possible from an improved Shuttle Data Collection system.
  - 2nd Gen starting up with goals dependent on reliability, maintainability and supportability. Current Shuttle Data Collection system is inadequate to support these goals. This is a prime opportunity to make a change that will greatly benefit the 2nd Gen effort.
  - Data Examples:
    - Actual power-on times at lowest possible indenture level
    - Fault detection, Isolation and Recovery (FDIR) times

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Back up Charts

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Shuttle RM&S Data Collection Background - More Detail

- ~'81-'87
  - Initial 5 flights - AFTEC - processing times (high level) - early cuts at MTBM and MTTR;
  - Shuttle Trend Analysis Report/Shuttle Trend Analysis Guidelines (STAR/STAG) - flows and timelines;
  - Pan American database for single flow (STS 61-B) - functional flow by OMI, task descriptions, manpower and headcounts for Shuttle Processing Contractor (SPC) level analysis;
  - "Xerox Database" from JSC of the Mission Operations organizations provided headcount by organizations - data subsequently reorganized out of any usefulness.
- ~'89-'93
  - Advanced Manned launch Systems (AMLS)/Personnel Launch Systems (PLS) studies - more insight into support functions (headcount, cost) and GSE for KSC functions - better info on mission operations (processing templates, timelines and headcounts)
- ~'92 - '95
  - First extensive R&M database - primarily PRACA - post Challenger info -frequency of maintenance actions by subsystem and headcounts;
  - First (still the only) O&S cost information - Access to Space Annual Recurring Cost Backup Report - cost by budget category - manpower and material costs;
  - KSC, LaRC, MSFC effort - identify shuttle RM&S data sources and content to support engineering analyses of current and future launch systems;
  - "Available Shuttle System Database Identification and Pathfinder RM&S Data Search" published. (see Following)
- ~'92-'98: Continuation of the '92 R&M Database- with the Shop Floor records providing maintenance info. Updated annually thru '98.
- ~82-Present: Continuous contact among various organizations, individuals and reports

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

KSC Data Source Summary

Table - KSC RM&S Database Investigation Summary

RM&S Charateristic	Metrics/ MOE	Method		Indenture Lvl					Data Source	KSC D.B. Capability	Database Comments
		Collect	Derive	1	2	3	4	5			
Reliability	No. Corrective Maint. Actions, Repairs	x		x	x	x	x	x	PRACA, NSLD	√	Add'l analysis req'd
	No. Failures - Standalone Ops, Inherent & Induced	x		x	x	x	x	x	PRACA, NSLD	√	Add'l data code analysis req'd
	No. Failures - Integrated Ops, Inherent & Induced	x		x	x	x	x	x	PRACA, NSLD	√	Add'l data code analysis req'd
	No. Failures - Flight/On-Orbit	x		x	x	x	x	x	PRACA, IFA	√	Add'l data code analysis req'd
	Mean Time Between Failures (MTBF), Failure Rate		x	x	x	x	x		PRACA, RCM Rpt.	-	
	Mean Time Between Crit. 1 Failures (MTBF.1)		x	x	x	x	x		PRACA, RCM Rpt.	-	
	Mean Cycles Between Failures (MCBF)		x	x	x	x	x		PRACA, RCM Rpt.	-	
	Mean Time Between Corrective Maint. (MTBCM)		x	x	x	x	x		PRACA, RCM Rpt.	-	
	Mean Time Between Replacement (MTBR)		x	x	x	x	x		PRACA, RCM Rpt.	-	
	Operational Power on Hours - Ground (Test & C/O)	x	x	x	x	x	x		PEARL, RCM, Bus	√*	Limited data collected in TACCS
	Operational Power on Hours - Flight/On-orbit	x	x	x	x	x	x		PEARL, RCM, Bus	√*	Limited data collected in TACCS
	No. Cycles - Ground (Test & C/O)	x	x	x	x	x	x		PEARL, RCM, Bus	√*	Limited data collected in TACCS
	No. Cycles - Flight/On-orbit	x	x	x	x	x	x		PEARL, RCM, Bus	√*	Limited data collected in TACCS
Maintainability	Mean Time To Repair, Mean Corr. Maint. Time (Mct)		x	x	x	x	x		IWCS, Collect	-	Not collected in KSC system
	Mean Preventive Maint. Time (Mpt)		x	x	x	x	x		CAPSS, GPSS, IWCS	-	TBD
	Mean Active Maintenance Time (M)		x	x	x	x	x		Mct, Mpt	-	Mct & Mpt summation
	Logistics Delay Time (LDT)	x		x	x	x	x		IWCS	√*	Limited info., add'l analysis req'd
	Administrative Delay Time (ADT)	x		x	x	x	x		IWCS	√*	Limited info., add'l analysis req'd
	Maintenance Downtime (MDT)		x	x	x	x	x		M, LDT, ADT	√	M, LDT & ADT summation
Labor	Manhours/Repair - On line/on site	x		x	x	x	x		IWCS	√*	Technician hours only
	Manhours/Repair - Off site depot/vendor	x				x	x		NSLD	-	Not available in KSC databases
	Maint. Manhours/Maint. Action (MMH/MA)		x	x	x	x	x		IWCS, Derive	√*	Technician hours only
	Maint. Manhours/Operating Hour (MMH/OH)		x	x	x	x	x		IWCS, Derive	-	
	Maint. Manhours/Ops Cycle (MMH/Cycle)		x	x	x	x	x		IWCS, Derive	-	
Cost	Cost/Mission Hour		x	x	x	x	x		TBD	-	
	Cost/Maint. Action ($/MA)		x	x	x	x	x		TBD	-	
	Cost/Operating Hour ($/OH)		x	x	x	x	x		TBD	-	
Availability	Inherent Availability (Ai)		x	x	x	x	x		MTBF, MTTR	-	
	Achieved Availability (Aa)		x	x	x	x	x		MTBM, M	-	
	Operational Availability (Ao)		x	x	x	x	x		MTBM & MDT	-	

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

Findings

- Total 65 data sources were evaluated, of which only those sources previously listed, proved to be valuable sources of RM&S/operations data.
- Limitations within the KSC database network included the lack of "direct" **traceability** to time/MTTR and subsequent labor hour/cost data.
- Orbiter systems **"power-on time"** was recorded differently (ie, estimated % of total hours vs actual recorded ground & flight power-on time), dependent on various directorate requirements and methodology.
- Reference Data Source Summary spreadsheet for Recurring Metrics data sources and methodology.

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov

BCS Conclusions

- KSC data sources reside primarily within the SPDMS-II network
- To achieve maximum BCS population in Phase 2, several SPDMS-II sub-databases should be utilized (PRACA, IWCS, IOS, SFC/DC, CAPSS, etc.)
- To gain electronic access to this SPDMS data, an interface to the off-line FRED/ADAM system should be established.
- *Phase 2 should remain a prototype demonstration activity to accomplish these tasks:*
  - Establish ad hoc query/automated data collection interface and capability
  - Determine extent/completeness of BCS metrics populated via automated data collection
  - Determine extent of "manual intervention" required to populate remaining BCS metrics
  - Update and populate (TBD) BCS metrics with current STS data via automated method(s)

Implementation of these tasks for Phase 2 should prove system viability and validity, but not necessarily populate all BCS Recurring Metrics

Jeff.morton@msfc.nasa.gov
Mike.nix@msfc.nasa.gov